tions have been made, several of which are recorded on the Table, and in health no cases have been found which depart from the curve more than those indicated on it.

The observations made on the author are represented by simple black dots, those made on others are encircled by a ring; great size of a dot indicates that more than one independent observation has produced exactly similar results.

In none of the cases have measurements been made after violent exercise. Differences in the height and age of the subjects experimented on have not been found to produce any appreciable effect.

The trace from infants has not been examined.

From the equation $xy = \sqrt[3]{x} \cdot k$ the length of the *second* part of the pulse trace may be represented in terms of x, as $\frac{k - \sqrt[3]{x^2}}{x \cdot k}$; and as from the nature of y it cannot be less than unity (no pulse having been seen with two contractions or more between two successive closures of the aortic valve), the limit of cardiac rapidity may be deduced to be 322 in a minute ($k=47$); but it is scarcely probable that pulses of such a rate could remain so sufficiently long to be counted.

In many cases of disease implicating the circulatory system, the equation given above indicates that the duration of the *first* part of the heart's action is not normal; thus, in a boy suffering from typhoid fever, on the second day after the pyrexia had ceased, and when the temperature was below the normal, xy was found $=225{\cdot}25$, where $x=60$, which differs from the equation

$$\sqrt[3]{67} \times 47 = 190{\cdot}82,$$

which shows that the length of the *first* part is considerably too short in the former. In the same case, three days later, the patient rapidly improving, with $x = 56{\cdot}5$,

$$xy = 188,$$

which is much nearer the calculated normal result, 180·5, than on the former occasion, the trace keeping pace with the other physical changes.

It is probable that many other imperfections in the circulatory system can be similarly indicated, and it has been shown above with what facility a diagnosis may be arrived at.

VI. "Spectroscopic Observations of the Sun."—No. VI.

By J. Norman Lockyer. Received April 27, 1870.

The weather lately has been fine enough and the sun high enough during my available observation-time to enable me to resume work.

The crop of new facts is not very large, not so large as it would have been had I been working with a strip of the sun, say fifty miles or a hundred miles wide, instead of one considerably over a thousand—indeed, nearer two thousand in width; but in addition to the new facts obtained, I have

very largely strengthened my former observations, so that the many hours I have spent in watching phenomena, now perfectly familiar to me, have not been absolutely lost.

The negative results which Dr. Frankland and myself have obtained in our laboratory-work in the matter of the yellow bright line, near D, in the spectrum of the chromosphere being a hydrogen line, led me to make a special series of observations on that line, with a view of differentiating it, if possible, from the line C.

It had been remarked, some time ago, by Professor Zollner, that the yellow line was often less high in a prominence than the C line; this, however, is no evidence (bearing in mind our results with regard to magnesium). The proofs I have now to lay before the Royal Society are of a different order, and are, I take it, conclusive :—

1. With a tangential slit I have seen the yellow line bright below the chromosphere, while the C line has been dark ; the two lines being in the same field of view.

2. In the case of a bright prominence over a spot *on the disk*, the C and F lines have been seen bright, while the yellow line has been invisible.

3. In a high-pressure injection of hydrogen, the motion indicated by change of wave-length has been *less* in the case of the yellow line than in the case of C and F.

4. In a similar quiescent injection the pressure indicated has been less.

5. In one case the C line was seen long and unbroken, while the yellow line was equally long, but *broken*.

The circumstance that this line is so rarely seen dark upon the sun makes me suspect a connexion between it and the line at 5015 Ångström, which is also a bright line, and often is seen bright in the chromosphere, and then higher than the sodium and magnesium lines, when they are visible at the same time ; and the question arises, must we not attribute these lines to a substance which exists at a higher temperature than those mixed with it, and to one of very great levity? for its absorption line remains invisible, as a rule, in spot spectra.

I have been able to make a series of observations on the fine spot which was visible when I commenced them on the 10th instant, not far from the centre of its path over the disk. At this time, the spot, as I judged by the almost entire absence of indications of general absorption in the penumbral regions, was shallow, and this has happened to many of the spots seen lately. A few hours' observation showed that it was getting deeper apparently, and that the umbræ were enlarging and increasing in number, as if a general downsinking were taking place ; but clouds came over, and the observations were interrupted.

By the next day (April 11) the spot had certainly developed, and now there was a magnificently bright prominence, completely over the darkest mass of umbra, the prominence being fed from the penumbra or very close to it, a fact indicated by greater brilliancy than in the bright C and F lines.

April 12. The prominence was persistent.

April 15. Spot nearing the limb, prominence still persistent over spot. At eleven I saw no prominence of importance on the limb, but about an hour afterwards I was absolutely startled by a prominence not, I think, depending upon the spot I have referred to, but certainly near it, more than 2′ high, showing a tremendous motion towards the eye. There were light clouds, which reflected to me the solar spectrum, and I therefore saw the black C line at the same time. The prominence C line (on which changes of wave-length are not so well visible as in the F line) was only coincident with the absorption-line for a few seconds of arc!

Ten minutes afterwards the thickness of the line towards the right was all the indication of motion I got. In another ten minutes the bright and dark lines were coincident.

And shortly afterwards what motion there was was towards the red!

I pointed out to the Royal Society, now more than a year ago *, that the largest prominences, *as seen at any one time,* are not necessarily those in which either the intensest action or the most rapid change is going on. From the observations made on this and the following day, I think that we may divide prominences into two classes :—

1. Those in which great action is going on, lower vapours being injected; in the majority of cases these are not high, they last only a short time—are throbs, and are oft renewed, and are not seen so frequently near the sun's poles as near the equator. They often accompany spots, but are not limited to them. These are the intensely bright prominences of the American photographs.

2. Those which are perfectly tranquil, so far as wave-length evidence goes. They are often high, are persistent, and not very bright. These do not, as a rule, accompany spots. These are the "radiance" and dull prominences shown in the American photographs.

I now return to my observations of the spot. On the 16th the last of the many umbræ was close to the limb, and the most violent action was indicated occasionally. I was working with the C line, and certainly never saw such rapid changes of wave-length before. The motion was chiefly horizontal, or nearly so, and this was probably the reason why, in spite of the great action, the prominences, three or four of which were shut out, never rose very high.

I append some drawings made, at my request, by an artist, Mr. Holiday, who happened to be with me, and who had never seen my instrument or the solar spectrum widely dispersed before. I attach great importance to them, as they are the untrained observations of a keen judge of form.

The appearances were at times extraordinary and new to me. The hydrogen shot out rapidly, scintillating as it went, and suddenly here and there the bright line, broad and badly defined, would be pierced, as it were, by a line of intensely brilliant light parallel to the length of the

* Proc. Roy. Soc. 1869, p. 354, Mar. 17.

spectrum, and at times the whole prominence spectrum was built up of bright lines so arranged, *indicating that the prominence itself was built up of single discharges,* shot out from the region near the limb with a velocity sometimes amounting to 100 miles a second. After this had gone on for a time, the prominence mounted, and the cyclonic motion became evident; for away from the sun, as shown in my sketch, the separate masses were travelling away from the eye; then gradually a background of less luminous hydrogen was formed, moving with various velocities, and on this background the separate "bombs" appeared (I was working with a vertical spectrum) like exquisitely jewelled ear-rings.

It soon became evident that the region of the chromosphere just behind that in which the prominence arose, was being *driven back* with a velocity something like 20 miles a second, the back-rush being so local that with the small image I am unfortunately compelled to use, both the moving and rigid portions were included in the thickness of the slit. I saw the two absorption-lines overlap.

These observations were of great importance to me; for the rapid action enabled me to put together several phenomena I was perfectly familiar with separately, and see their connected meaning.

They may be summarized as follows, and it will be seen that they teach us much concerning the nature of prominences. When the air is perfectly tranquil in the neighbourhood of a large spot, or, indeed, generally in any part of the disk, we see absorption-lines running along the whole length of the spectrum, crossing the Fraunhofer lines, and they vary in depth of shade and breadth according as we have pore, corrugation, or spot under the corresponding part of the slit,—a pore, in fact, is a spot. Here and there, where the spectrum is brightest (where a bright point of facula is under the slit), we suddenly see an interesting bright lozenge of light. This I take to be due to bright hydrogen at a greater pressure than ordinary, and this then is the reason of the intensely bright points seen in ranges of faculæ observed near the limb.

The appearance of this lozenge in the spectroscope, which indicates a diminution of pressure round its central portion, is the signal for some, and often all of the following phenomena:—

1. A thinning and strange variations in the visibility and thickness of the hydrogen absorption-line under observation.

2. The appearance of other lozenges in the same locality.

3. The more or less decided formation of a bright prominence on the disk.

4. If near the limb, this prominence may extend beyond it, and its motion-form will then become more easy of observation. In such cases the motion is cyclonic in the majority of cases, and generally very rapid, and—another feature of a solar storm—the photospheric vapours are torn up with the intensely bright hydrogen, *the number of bright lines visible*

determining the depth from which the vapours are torn, and varying almost directly with the amount of motion indicated.

Here, then, we have, I think, the chain that connects the prominences with the brighter points of the faculæ.

These lozenge-shaped appearances, which were observed close to the spot on the 16th, were accompanied by the "throbs" of the eruption, to which I have before referred; while Mr. Holiday was with me—a space of two hours—there were two outbursts, separated by a state of almost rest, and each outburst consisting of a series of discharges, as I have shown. I subsequently witnessed a third outburst. The phenomena observed on all three were the same in kind.

On this day I was so anxious to watch the various motion-forms of the hydrogen-lines, that I did not use the tangential slit. This I did the next day (the 17th of April) in the same region, when similar eruptions were visible, though the spot was no longer visible.

Judge of my surprise and delight, when upon sweeping along the spectrum, I found HUNDREDS of the Fraunhofer lines beautifully bright at the base of the prominence!!!

The complication of the chromosphere spectrum was greatest in the regions more refrangible than C, from E to long past *b* and near F, and high-pressure iron vapour was one of the chief causes of the phenomenon.

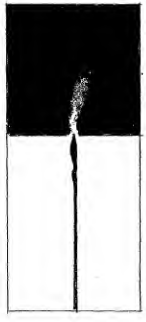
I have before stated to the Royal Society that I have seen the chromosphere full of lines; but the fullness then was as emptiness compared with the observation to which I now refer.

A more convincing proof of the theory of the solar constitution, put forward by Dr. Frankland and myself, could scarcely have been furnished. This observation not only endorses all my former work in this direction, but it tends to show the shallowness of the region on which many of the more important solar phenomena take place, as well as its exact locality.

The appearance of the F line, with a tangential slit at the base of the prominence, included two of the lozenge-shaped brilliant spots to which I have before referred; they were more elongated than usual—an effect of pressure, I hold—greater pressure and therefore greater complication of the chromosphere spectrum. This complication is almost impossible of observation on the disk.

It is noteworthy that in another prominence, on the same side of the sun, although the action was great, the erupted materials were simple, *i. e.* only sodium and magnesium, and that a moderate alteration of wave-length in these vapours was obvious.

Besides these observations on the 17th, I also availed myself of the pureness of the air to telescopically examine the two spots on the disk, which the spectroscope reported tranquil as to up and down rushes. I saw every cloud-dome in their neighbourhood perfectly, and I saw these domes drawn out, by horizontal currents doubtless, in the penumbræ,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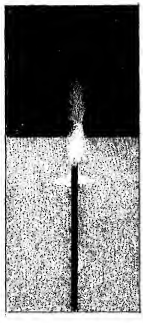
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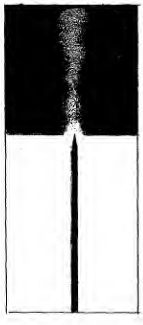
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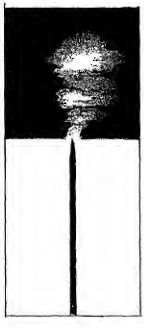
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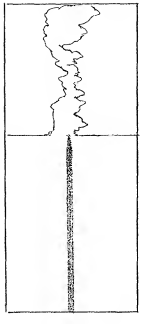
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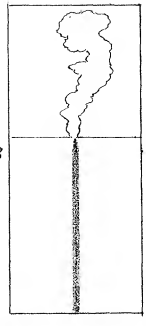
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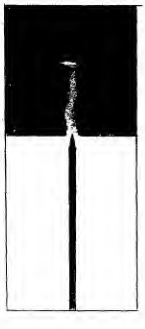
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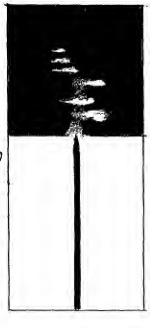
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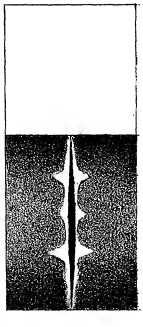
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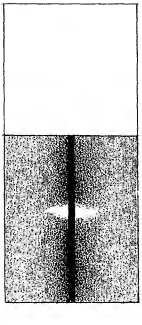
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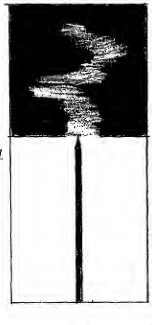
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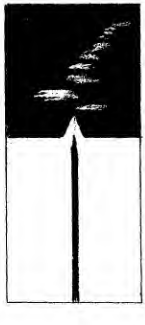
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while on the floors of the spots, here and there, were similar single cloud-masses, the distribution of which varied from time to time, the spectrum of these masses resembling that of their fellows on the general surface of the sun.

I have before stated that the region of a spot comprised by the penumbra appears to be shallower in the spots I have observed lately (we are now near the maximum period of sun spots); I have further to remark that I have evidence that the chromosphere is also shallower than it was in 1868.

I am now making special observations on these two points, as I consider that many important conclusions may be drawn from them.

DESCRIPTION OF PLATE III.

Mr. Holiday's drawings and remarks.

1. Prominence much bent.
2. Prominence encroaching over limb—bright line crossing black line.
3. Black line (F) curved downwards, sometimes nearly touching iron line below.
4.
5. Prominence nearly divided.
6. Intensely brilliant flashes above and below centres (of F lines); the interruptions very complete.

7 & 8. Curves in prominence very marked.

9, 10, 12, 14, 15. My own drawings, made during first and second outbursts.

11. A lozenge on the limb as seen with a tangential slit.

13. A lozenge as seen on the sun itself.

VII. "On some Elementary Principles in Animal Mechanics.—No. IV. On the difference between a Hand and a Foot, as shown by their Flexor tendons." By the Rev. Samuel Haughton, F.R.S., M.D. Dubl., D.C.L. Oxon., Fellow of Trinity College, Dublin. Received April 23, 1870.

The fore feet of vertebrate animals are often used merely as organs of locomotion, like the hind feet; and in the higher mammals they are more or less "cephalized," or appropriated as hands to the use of the brain.

The proper use of a hand when thus specialized in its action, is to grasp objects; while the proper use of a foot is to propel the animal forward by the intervention of the ground.

In the case of the hand, the flexor muscles of the fore arm act upon the finger tendons, in a direction from the muscles towards the tendons, which latter undergo friction at the wrist and other joints of the hand, the force being applied by the muscles to the tendon above the wrist, and the resistance being applied at the extremities of the tendons below the wrist by the object grasped by the hand.

From the principle of "Least Action in Nature" we are entitled to assume the strength of each portion of a tendon to be proportional to the force it is required to transmit; and since, in a proper hand, these forces are continually diminished by friction, as we proceed from the muscle to